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RESEARCH ARTICLE

# Can guava monocultures (*Psidium guajava* L.) function as refuge for bird conservation?

Cleverton da Silva[1], Juan Ruiz-Esparza[2,3], Fabiana Oliveira da Silva[2,3], Cristiano Schetini de Azevedo[4], Adauto de Souza Ribeiro[5]

1 *Universidade Federal de Sergipe, Programa de Pós-Graduação em Desenvolvimento e Meio Ambiente, Av. Marechal Rondon s/n, CEP: 49100-100, São Cristóvão, SE, Brazil*
2 *Universidade Federal de Sergipe, Núcleo em Educação em Ciências Agrárias e da Terra, Rod. Engenheiro Jorge Neto, Km 3, Silos, CEP: 49680-000, Nossa Senhora da Glória, SE, Brazil*
3 *Instituto Nacional de Ciência e Tecnologia em Estudos Interdisciplinares e Transdisciplinares em Ecologia e Evolução (INCT IN-TREE), Nossa Senhora da Glória, SE, Brazil*
4 *Universidade Federal de Ouro Preto, Programa de Pós-Graduação em Ecologia de Biomas Tropicais, Departamento de Biodiversidade, Evolução e Meio Ambiente, Instituto de Ciências Exatas e Biológicas, Morro do Cruzeiro s/n, CEP: 35400-000, Ouro Preto, MG, Brazil*
5 *Universidade Federal de Sergipe, Departamento de Ecologia, Av. Marechal Rondon s/n, CEP: 49100-100, São Cristóvão, SE, Brazil*

Corresponding author: Cleverton da Silva (silvac.bio@gmail.com)

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## Abstract

Agricultural intensification negatively affects bird communities, and the response of birds to these changes varies from those that survive and increase their populations (disturb-tolerant species) to those that cannot adapt to new conditions and are regionally extinct (disturb-sensitive species). Thus, the present study sought to investigate the bird community in 39 guava orchards in the semiarid region of the state of Sergipe, northeast Brazil. Field observations were made between July and October 2017, through a one-hour visit to each orchard. Samplings were conducted using the MacKinnon's List method. In addition to bird sampling, walks were carried out in the orchards to observe nesting. Seventy-six species of birds belonging to 30 families were recorded using the guava orchards. The most frequent species were *Vanellus chilensis*, *Columbina talpacoti*, *Columbina picui*, *Crotophaga ani*, *Pitangus sulphuratus* and *Sporophila albogularis*. Of the 186 nests recorded in the orchards, the majority (n = 144 nests; 77.4%) belonged to *Columbina picui*, *Columbina talpacoti* and *Columbina minuta*.

The results demonstrate that the bird community in the guava orchards is formed only by disturb-tolerant species, showing that the studied guava orchards are not favorable to the conservation of disturb-sensitive birds of the Caatinga domain.

**Keywords**
Agricultural environment, biodiversity-friendly agriculture, guava orchards, semiarid

## Introduction

Agriculture is one of the greatest threats to biodiversity (Foley et al. 2005, 2011; Laurance et al. 2014; Barlow et al. 2016), especially in the tropics, where it is the main cause of deforestation (Tilman et al. 2001; Geist and Lambin 2002; Donald 2004; Malhi et al. 2014). The response of birds to this modification varies from those more tolerant to habitat changes, which are able to find food and other resources necessary for their survival and ended increasing their populations (disturbed-tolerant species), to those sensitive to this new condition and ended regionally extinct (disturbed-sensitive species) (Marini and Garcia 2005; Perfecto and Vandermeer 2008). Thus, a great challenge for conservationists is to reconcile the growing demand for world agricultural production with the consequent decline in biological diversity (Harvey et al. 2008; Tavares et al. 2019).

The effects of agricultural intensification on biodiversity have been widely studied in recent decades (Tscharntke et al. 2005; Jeliazkov et al. 2016; Stanton et al. 2018; Şekercioğlu et al. 2019; Tavares et al. 2019; Göpel et al. 2020; Smith et al. 2020). As a result, several conceptual land management commitments, such as organic agriculture, the reduction and elimination of chemical pesticides and the use of fire, as well as the maintenance of remnants of native forest fragments, were proposed to reconcile agricultural production with the conservation of biodiversity and, consequently, guarantee the environmental sustainability of agricultural activities. However, to achieve these goals, new research, policies, and incentives for agri-environmental regimes and the adoption of agriculture and practices favorable to the maintenance of species in agricultural environments are needed (Herzon and Mikk 2007).

According to Petit and Petit (2003), some cultivated areas are important for the conservation of Neotropical birds, recognizing that plantations that offer a degree of shading to the environment are important for harboring species related to different environments. Coffee plantations, for example, can provide important habitat for many bird species in agricultural areas (Petit and Petit 2003; Tejeda-Cruz and Sutherland 2004; Leyequién et al. 2010; Hernandez et al. 2013; Buechley et al. 2015). Other studies have demonstrated the importance of irrigated rice farming for some species was associated to bodiesientes aquáticos, especially as a place for feeding and resting (Fasola and Ruiz 1996, 1997; López-Lanús et al. 2007; Eadie et al. 2008). Beecher et al. (2002) showed that bird richness and abundance in organic farmlands were two to almost three times higher than in nonorganic farmlands in Nebraska (USA).

Although birds have been surveyed in various agricultural crops worldwide (e.g., Bennett et al. 2006; Fischer et al. 2008; Fahrig et al. 2011), Brazilian crops

have been poorly studied, despite Brazil's global importance for both agriculture and biodiversity (Alexandrino et al. 2019). As a result, data on species occurrence and crop usage is scarce.

The guava (*Psidium guajava* L.), originally from the American tropics, is one of the most common and economically important fruit trees in the tropical and subtropical regions of the world (Gonçalves et al. 2016). In Brazil, guava is grown on a commercial scale in practically all regions (Pereira and Ryosuke 2011). In the Northeast region of Brazil, where a semiarid climate predominates, this crop has been expanded, mainly due to favorable climatic conditions and advanced irrigation techniques (Barbosa and Lima 2010). However, despite its commercial relevance, there are almost no studies in Brazil on the avifauna in these environments (Silva et al. 2019, 2021), making its role as a complementary environment for the conservation of avifauna unknown. According to Verdade et al. (2014), understanding which species use different agricultural crops and the purpose of this use can help in the design of biodiversity-friendly agriculture. In this sense, this study aimed to investigate the bird community in guava orchards in the semiarid region of state of Sergipe, Northeast Brazil, to evaluate if this culture can act as bird conservation remnant in this region. The results found can generate knowledge and subsidies for planning more ecological and sustainable agriculture, where it is possible to reconcile food production with conservation of biodiversity.

## Material and methods

### Study area

The study was conducted in 39 guava orchards, in the agricultural settlements California and Jacaré-Curituba, located in the territory of Alto Sertão Sergipe in the northwestern part of the Brazilian state of Sergipe, covering areas of the municipalities of Canindé de São Francisco (09°38'31"S, 37°47'16"W) and Poço Redondo (06°48'21"S, 37°41'06"W) (Fig. 1). The settlements follow the model based on conventional agriculture, mostly polycultures, and agriculture/livestock consortium, surrounded by native areas of Caatinga, a Brazilian biome characterized by desert-like vegetation, resulting from the current land use model (Silva et al. 2019). The plots for cultivation are contiguous and due to the small size of the production units (1 to 10 ha) it is possible to completely remove the native vegetation and replace it with crops and pastures (Silva et al. 2019). Among the crops produced in the settlements, legumes, vegetables, and fruits stand out, with okra, cassava, corn, beans, acerola and guava the main crops exploited by producers (Silva et al. 2019).

The guava orchards sampled are approximately 12 years old and some have small lakes, used for irrigation. Exotic grasses, like *Megathyrsus maximus*, can be observed in all sampled orchards, growing among the guava tree lines. The region's climate is classified as Bsh, according to the Köppen classification – dry and hot semiarid, characterized by lack of rain with great irregularity in its distribution, high evaporation rates and average temperatures above 25 °C (Silva et al. 2019).

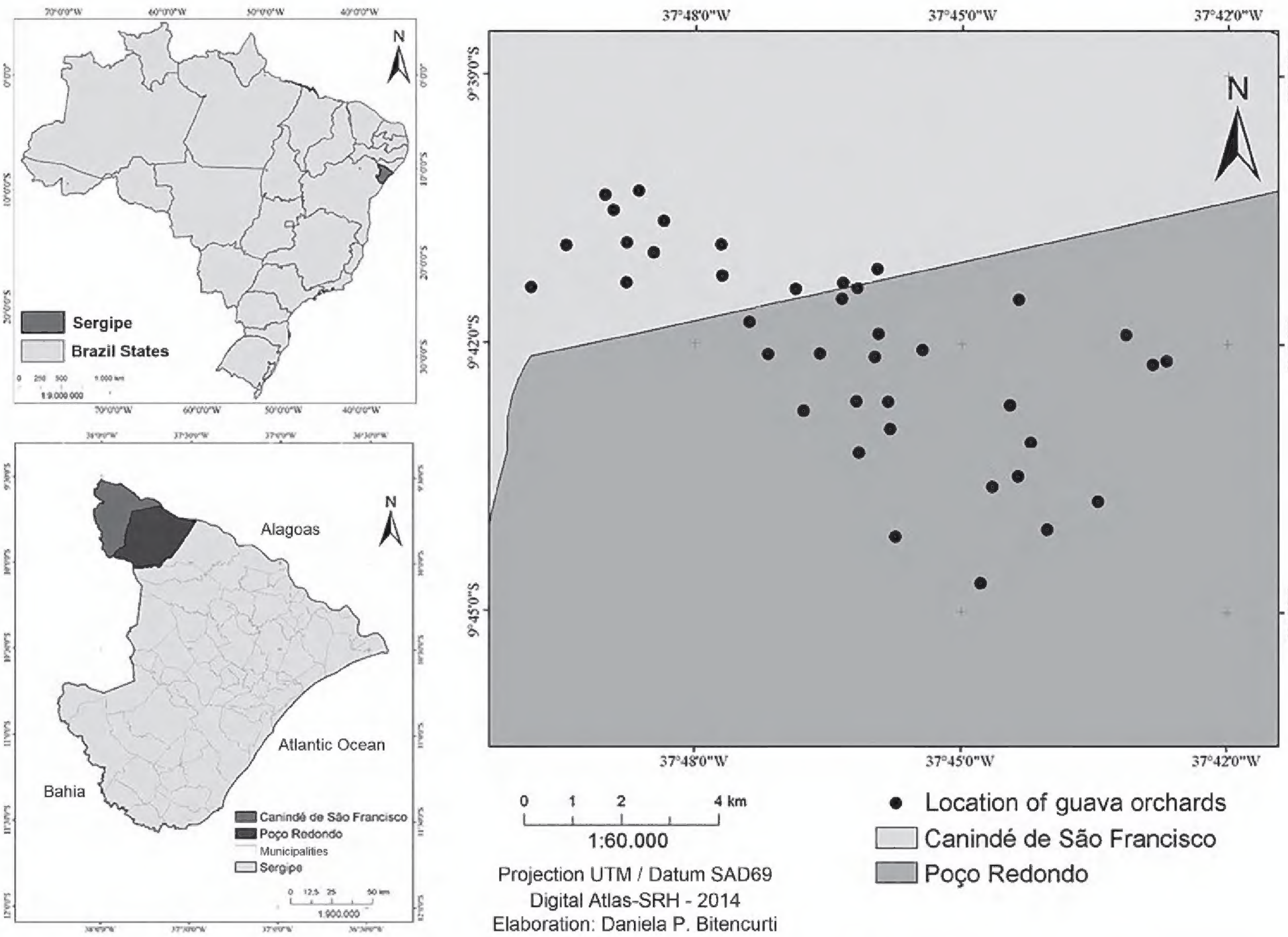


**Figure 1.** Location of the 39 guava orchards sampled in the California and Jacaré-Curituba agricultural settlements in Canindé de São Francisco and Poço Redondo, state of Sergipe, northeastern Brazil.

## Data collection and analysis

Bird sampling occurred between July and October 2017, through a single one-hour visit to each orchard, in the early hours of the day (between 6 and 11:00 h am). The MacKinnon Lists method (Mackinnon and Phillips 1993; Ribon 2010) was used to carry out the samplings, through visual and/or auditory contacts, with the aid of 10×42 binoculars and field guide (Sigrist 2009). Species that only flew over the orchards, without any interaction with them, were not considered.

The taxonomic classification and nomenclature of the species followed the most up-to-date resolutions of the Brazilian Committee of Ornithological Records (Pacheco et al. 2021). The determination of trophic groups was based on field observations and literature data (Wilman et al. 2014). The List of Brazilian Fauna Threatened with Extinction (MMA 2014) and the International Union for Conservation of Nature (IUCN 2021) were used to evaluate the extinction risk of the recorded species. The verification of the geographic distribution and possible endemism was based on Stotz et al. (1996) and Olmos et al. (2005).

To verify species richness and evaluate the efficiency of the sampling effort in the orchards, a rarefaction curve was constructed based on the samples. We used the Chao 2 richness estimator (indicated for incidence data) to estimate how many species could be detected based on observed richness (Gotelli and Colwell 2011;

Chao and Chiu 2016), using the EstimateS 8.0 program (Colwell 2006). The relative abundance of species was calculated by dividing the number of lists in which each species was recorded by the total number of lists obtained at the end of the work, obtaining the List Frequency Index (IFL) (Ribon 2010).

In addition to bird sampling, walks were carried out in the orchards to observe nests. When located, the nests were photographed, counted, and registered in a field spreadsheet, together with the species using the nest.

## Results

Through 83 MacKinnon lists, 76 bird species were registered, distributed in 30 families (Table 1), with Tyrannidae and Thraupidae being the most representative in number of species (n = 9 species), followed by Columbidae and Icteridae (n = 6 species) and Tinamidae, Ardeidae, Throchilidae and Furnariidae (n = 4 species). Among these, five species were endemic to the Caatinga (*Eupsittula cactorum*, *Pseudoseisura cristata*, *Agelaioides fringillarius*, *Paroaria dominicana*, and *Sporophila albogularis*). None of the species registered in this study are included in the list of endangered species of MMA (2014) and IUCN (2021). The rarefaction curve showed a slight tendency to stabilization (Fig. 2). The species registered represent 86% of the estimated species, according to the Chao 2 richness estimator, which suggests at least 12 new species to be registered if the sampling effort is expanded.

The Eared Dove (*Zenaida auriculata*), a migratory species that can be seen in large flocks (Sick 1997), was the most abundant species, with 2.304 detected individuals (44%). However, the species *Vanellus chilensis* (IFL: 0.49), *Sporophila albogularis*

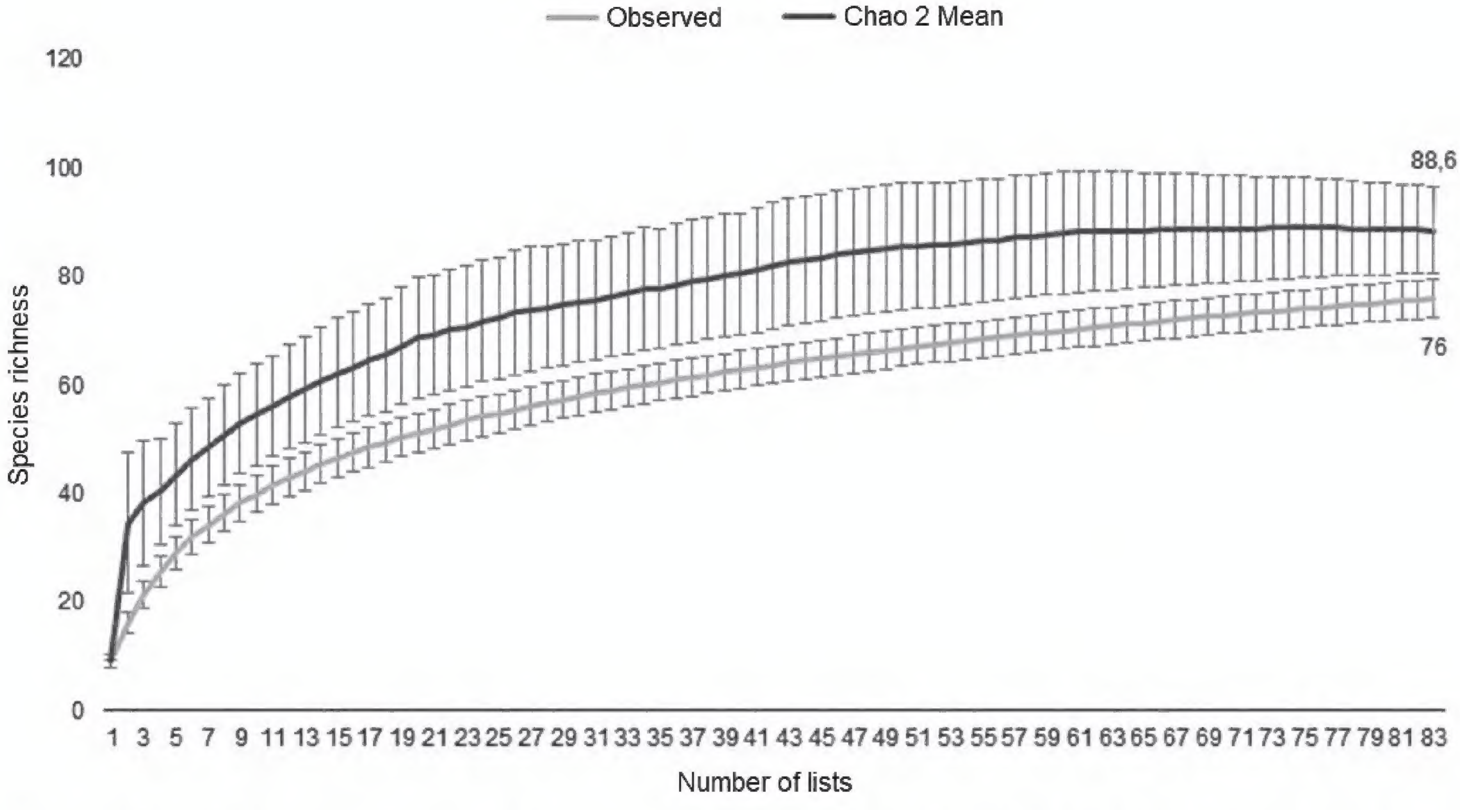


**Figure 2.** Rarefaction curve for observed and estimated bird richness (Chao 2) in the sampled guava orchards in Sergipe, northeastern Brazil.

**Table 1.** Bird species recorded in the sampled guava orchards in Sergipe, northeastern Brazil. IFL: List Frequency Index; NI – Number of individuals observed; TG (Trophic group): CA – Carnivorous, GR – Granivorous, NE – Nectarivorous, GR/FR – Granivorous/Frugivorous, IN – Insectivorous, ON – Omnivorous and PI – Piscivorous.

| Taxon | Common name | NI | IFL | TG |
|---|---|---|---|---|
| Tinamidae Gray, 1840 | | | | |
| *Crypturellus parvirostris* (Wagler, 1827) | Small-billed Tinamou | 40 | 0.32 | ON |
| *Crypturellus tataupa* (Temminck, 1815) | Tataupa Tinamou | 12 | 0.10 | ON |
| *Nothura boraquira* (Spix, 1825) | White-bellied Nothura | 5 | 0.03 | ON |
| *Nothura maculosa* (Temminck, 1815) | Spotted Nothura | 6 | 0.07 | ON |
| Podicipedidae Bonaparte, 1831 | | | | |
| *Tachybaptus dominicus* (Linnaeus, 1766) | Least Grebe | 3 | 0.01 | ON |
| Ardeidae Leach, 1820 | | | | |
| *Tigrisoma lineatum* (Boddaert, 1738) | Rufescent Tiger-Heron | 2 | 0.02 | ON |
| *Butorides striata* (Linnaeus, 1758) | Striated Heron | 3 | 0.02 | ON |
| *Bubulcus ibis* (Linnaeus, 1758) | Cattle Egret | 342 | 0.31 | ON |
| *Ardea alba* Linnaeus, 1758 | Great Egret | 8 | 0.03 | ON |
| Accipitridae Vigors, 1824 | | | | |
| *Rupornis magnirostris* (Gmelin, 1788) | Roadside Hawk | 6 | 0.07 | ON |
| Rallidae Rafinesque, 1815 | | | | |
| *Pardirallus nigricans* (Vieillot, 1819) | Blackish Rail | 2 | 0.01 | ON |
| *Gallinula galeata* (Lichtenstein, 1818) | Common Gallinule | 2 | 0.01 | ON |
| Charadriidae Leach, 1820 | | | | |
| *Vanellus chilensis* (Molina, 1782) | Southern Lapwing | 167 | 0.49 | ON |
| Jacanidae Chenu & Des Murs, 1854 | | | | |
| *Jacana jacana* (Linnaeus, 1766) | Wattled Jacana | 3 | 0.01 | ON |
| Columbidae Leach, 1820 | | | | |
| *Columbina minuta* (Linnaeus, 1766) | Plain-breasted Ground-Dove | 140 | 0.31 | GR |
| *Columbina talpacoti* (Temminck, 1811) | Ruddy Ground-Dove | 168 | 0.45 | GR |
| *Columbina picui* (Temminck, 1813) | Picui Ground-Dove | 184 | 0.45 | GR |
| *Patagioenas picazuro* (Temminck, 1813) | Picazuro Pigeon | 5 | 0.06 | GR |
| *Zenaida auriculata* (Des Murs, 1847) | Eared Dove | 2304 | 0.37 | GR |
| *Leptotilla verreauxi* Bonaparte, 1855 | White-tipped Dove | 1 | 0.01 | GR |
| Cuculidae Leach, 1820 | | | | |
| *Coccyzus melacoryphus* Vieillot, 1817 | Dark-billed Cuckoo | 5 | 0.06 | IN |
| *Crotophaga ani* Linnaeus, 1758 | Smooth-billed Ani | 217 | 0.45 | IN |
| *Guira guira* (Gmelin, 1788) | Guira Cuckoo | 33 | 0.12 | ON |
| Strigidae Leach, 1820 | | | | |
| *Athene cunicularia* (Molina, 1782) | Burrowing Owl | 4 | 0.03 | ON |
| Trochilidae Vigors, 1825 | | | | |
| *Phaethornis ruber* (Linnaeus, 1758) | Reddish Hermit | 1 | 0.01 | NE |
| *Eupetomena macroura* (Gmelin, 1788) | Swallow-tailed Hummingbird | 16 | 0.14 | NE |
| *Chrysolampis mosquitos* (Linnaeus, 1758) | Ruby-topaz Hummingbird | 2 | 0.02 | NE |
| *Chlorostilbon lucidus* (Shaw, 1812) | Glittering-bellied Emerald | 6 | 0.06 | NE |
| Alcedinidae Rafinesque, 1815 | | | | |
| *Chloroceryle amazona* (Latham, 1790) | Amazon Kingfisher | 2 | 0.01 | PI |
| Bucconidae Horsfield, 1821 | | | | |
| *Nystalus maculatus* (Gmelin, 1788) | Spot-backed Puffbird | 4 | 0.02 | ON |
| Falconidae Leach, 1820 | | | | |
| *Caracara plancus* (Miller, 1777) | Southern Caracara | 18 | 0.16 | ON |
| *Herpetotheres cachinnans* (Linnaeus, 1758) | Laughing Falcon | 1 | 0.01 | CA |
| Psittacidae Rafinesque, 1815 | | | | |
| *Eupsittula cactorum* (Kuhl, 1820) | Cactus Parakeet | 62 | 0.16 | GR/FR |
| *Forpus xanthopterygius* (Spix, 1824) | Blue-winged Parrotlet | 101 | 0.26 | GR/FR |
| Furnariidae Gray, 1840 | | | | |
| *Furnarius rufus* (Gmelin, 1788) | Rufous Hornero | 12 | 0.08 | IN |

| Taxon | Common name | NI | IFL | TG |
|---|---|---|---|---|
| *Pseudoseisura cristata* (Spix, 1824) | Caatinga Cacholote | 49 | 0.30 | IN |
| *Phacellodomus rufifrons* (Wied, 1821) | Rufous-fronted Thornbird | 6 | 0.02 | IN |
| *Certhiaxis cinnamomeus* (Gmelin, 1788) | Yellow-chinned Spinetail | 8 | 0.03 | IN |
| Rhynchocyclidae Berlepsch, 1907 | | | | |
| *Todirostrum cinereum* (Linnaeus, 1766) | Common Tody-Flycatcher | 35 | 0.25 | IN |
| *Hemitriccus margaritaceiventer* (d'Orbigny & Lafresnaye, 1837) | Pearly-vented Tody-tyrant | 1 | 0.01 | IN |
| Tyrannidae Vigors, 1825 | | | | |
| *Camptostoma obsoletum* (Temminck, 1824) | Southern Beardless-Tyrannulet | 2 | 0.02 | IN |
| *Elaenia flavogaster* (Thunberg, 1822) | Yellow-bellied Elaenia | 1 | 0.01 | ON |
| *Machetornis rixosa* (Vieillot, 1819) | Cattle Tyrant | 3 | 0.02 | IN |
| *Pitangus sulphuratus* (Linnaeus, 1766) | Great Kiskadee | 83 | 0.43 | ON |
| *Myiozetetes similis* (Spix, 1825) | Social Flaycatcher | 11 | 0.07 | ON |
| *Tyrannus melancholicus* Vieillot, 1818 | Tropical Kingbird | 50 | 0.25 | IN |
| *Empidonomus varius* (Vieillot, 1818) | Variegated Flaycacher | 1 | 0.01 | IN |
| *Fluvicola nengeta* (Linnaeus, 1766) | Masked Water-Tyrant | 18 | 0.10 | IN |
| *Xolmis irupero* (Vieillot, 1823) | White Monjita | 1 | 0.01 | IN |
| Vireonidae Swainson, 1837 | | | | |
| *Cyclarhis gujanensis* (Gmelin, 1789) | Rufous-browed Peppershrike | 4 | 0.04 | ON |
| Troglodytidae Swainson, 1831 | | | | |
| *Troglodytes musculus* Naumann, 1823 | Southern House Wren | 37 | 0.25 | IN |
| *Cantorchilus longirostris* (Vieillot, 1819) | Long-billed Wren | 2 | 0.02 | IN |
| Polioptilidae Baird, 1858 | | | | |
| *Polioptila plumbea* (Gmelin, 1788) | Tropical Gnatcatcher | 32 | 0.19 | IN |
| Turdidae Rafinesque, 1815 | | | | |
| *Turdus rufiventris* Vieillot, 1818 | Rufous-bellied Thrush | 14 | 0.08 | ON |
| Mimidae Bonaparte, 1853 | | | | |
| *Mimus saturninus* (Lichtenstein, 1823) | Chalk-browed Mockingbird | 33 | 0.13 | ON |
| Motacillidae Horsfield, 1821 | | | | |
| *Anthus lutescens* Pucheran, 1855 | Yellowish Pipit | 11 | 0.08 | IN |
| Passerellidae Cabanis & Heine, 1850 | | | | |
| *Zonotrichia capensis* (Statius Muller, 1776) | Rufous-collared Sparrow | 1 | 0.01 | GR |
| *Ammodramus humeralis* (Bosc, 1792) | Grassland Sparrow | 56 | 0.26 | GR |
| Icteridae Vigors, 1825 | | | | |
| *Icterus pyrrhopterus* (Vieillot, 1819) | Variable Oriole | 3 | 0.02 | ON |
| *Icterus jamacaii* (Gmelin, 1788) | Campo Troupial | 1 | 0.01 | ON |
| *Gnorimopsar chopi* (Vieillot, 1819) | Chopi Blackbird | 3 | 0.01 | ON |
| *Chrysomus ruficapillus* (Vieillot, 1819) | Chestnut-capped Blackbird | 108 | 0.12 | ON |
| *Agelaioides fringillarius* (Spix, 1824) | Pale Baywing | 45 | 0.09 | ON |
| *Molothrus bonariensis* (Gmelin, 1789) | Shiny Cowbird | 59 | 0.16 | ON |
| Thraupidae Cabanis, 1847 | | | | |
| *Paroaria dominicana* (Linnaeus, 1758) | Red-cowled Cardinal | 12 | 0.10 | GR |
| *Tangara sayaca* (Linnaeus, 1766) | Sayaca Tanager | 77 | 0.26 | ON |
| *Sicalis flaveola* (Linnaeus, 1766) | Saffron Finch | 2 | 0.02 | GR |
| *Volatinia jacarina* (Linnaeus, 1766) | Blue-black Grassquit | 305 | 0.24 | GR |
| *Corysphopingus pileatus* (Wied, 1821) | Pileated Finch | 1 | 0.01 | GR |
| *Coereba flaveola* (Linnaeus, 1758) | Bananaquit | 7 | 0.04 | ON |
| *Sporophila nigricollis* (Vieillot, 1823) | Yellow-bellied Seedeater | 12 | 0.04 | GR |
| *Sporophila albogularis* (Spix, 1825) | White-throated Seedeater | 133 | 0.48 | GR |
| *Compsothraupis loricata* (Lichtenstein, 1819) | Scarlet-throated Tanager | 6 | 0.01 | ON |
| Fringillidae Leach, 1820 | | | | |
| *Euphonia chlorotica* (Linnaeus, 1766) | Purple-throated Euphonia | 51 | 0.31 | ON |
| Estrildidae Bonaparte, 1850 | | | | |
| *Estrilda astrid* (Linnaeus, 1758) | Common Waxbill | 19 | 0.04 | GR |
| Passeridae Rafinesque, 1815 | | | | |
| *Passer domesticus* (Linnaeus, 1758) | House Sparrow | 6 | 0.02 | ON |

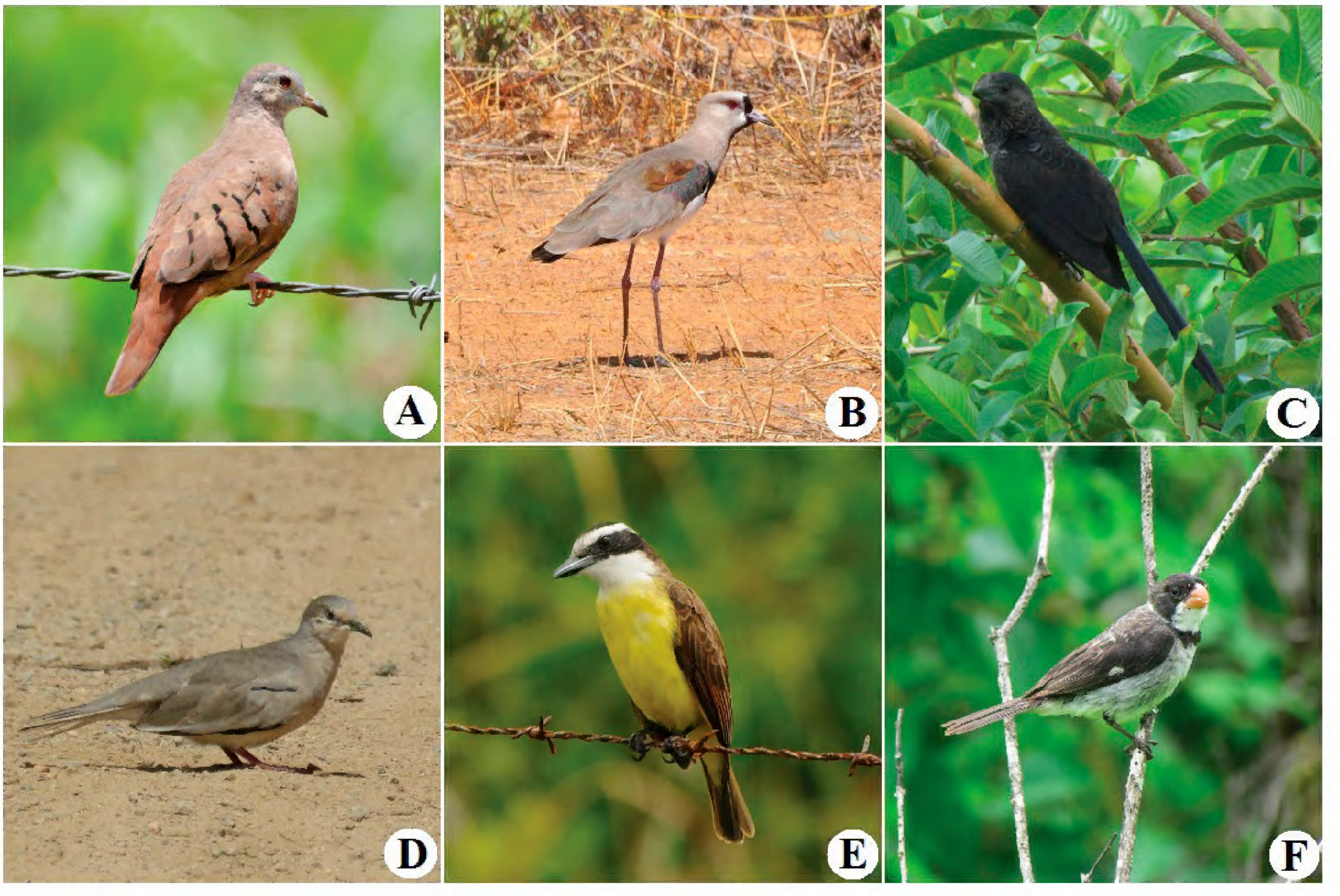


**Figure 3.** Most frequent bird species in the sampled guava orchards in Sergipe, northeastern Brazil. A) *Columbina talpacoti*, B) *Vanellus chilensis*, C) *Crotophaga ani*, D) *Columbina picui*, E) *Pitangus sulphuratus*, F) *Sporophila albogularis*. Photos: Cleverton da Silva.

**Table 2.** Bird species observed using the sampled guava orchards, located in Sergipe, northeastern Brazil, for nesting.

| Taxon | Common name |
|---|---|
| Tinamidae Gray, 1840 | |
| *Crypturellus parvirostris* (Wagler, 1827) | Small-billed Tinamou |
| Columbidae Leach, 1820 | |
| *Columbina minuta* (Linnaeus, 1766) | Plain-breasted Ground-Dove |
| *Columbina talpacoti* (Temminck, 1811) | Ruddy Ground-Dove |
| *Columbina picui* (Temminck, 1813) | Picui Ground-Dove |
| Cuculidae Leach, 1820 | |
| *Crotophaga ani* Linnaeus, 1758 | Smooth-billed Ani |
| Furnariidae Gray, 1840 | |
| *Furnarius rufus* (Gmelin, 1788) | Rufous Hornero |
| *Phacellodomus rufifrons* (Wied, 1821) | Rufous-fronted Thornbird |
| Tyrannidae Vigors, 1825 | |
| *Fluvicola nengeta* (Linnaeus, 1766) | Masked Water-Tyrant |
| Polioptilidae Baird, 1858 | |
| *Polioptila plumbea* (Gmelin, 1788) | Tropical Gnatcatcher |
| Turdidae Rafinesque, 1815 | |
| *Turdus rufiventris* Vieillot, 1818 | Rufous-bellied Thrush |
| Mimidae Bonaparte, 1853 | |
| *Mimus saturninus* (Lichtenstein, 1823) | Chalk-browed Mockingbird |
| Thraupidae Cabanis, 1847 | |
| *Sporophila albogularis* (Spix, 1825) | White-throated Seedeater |

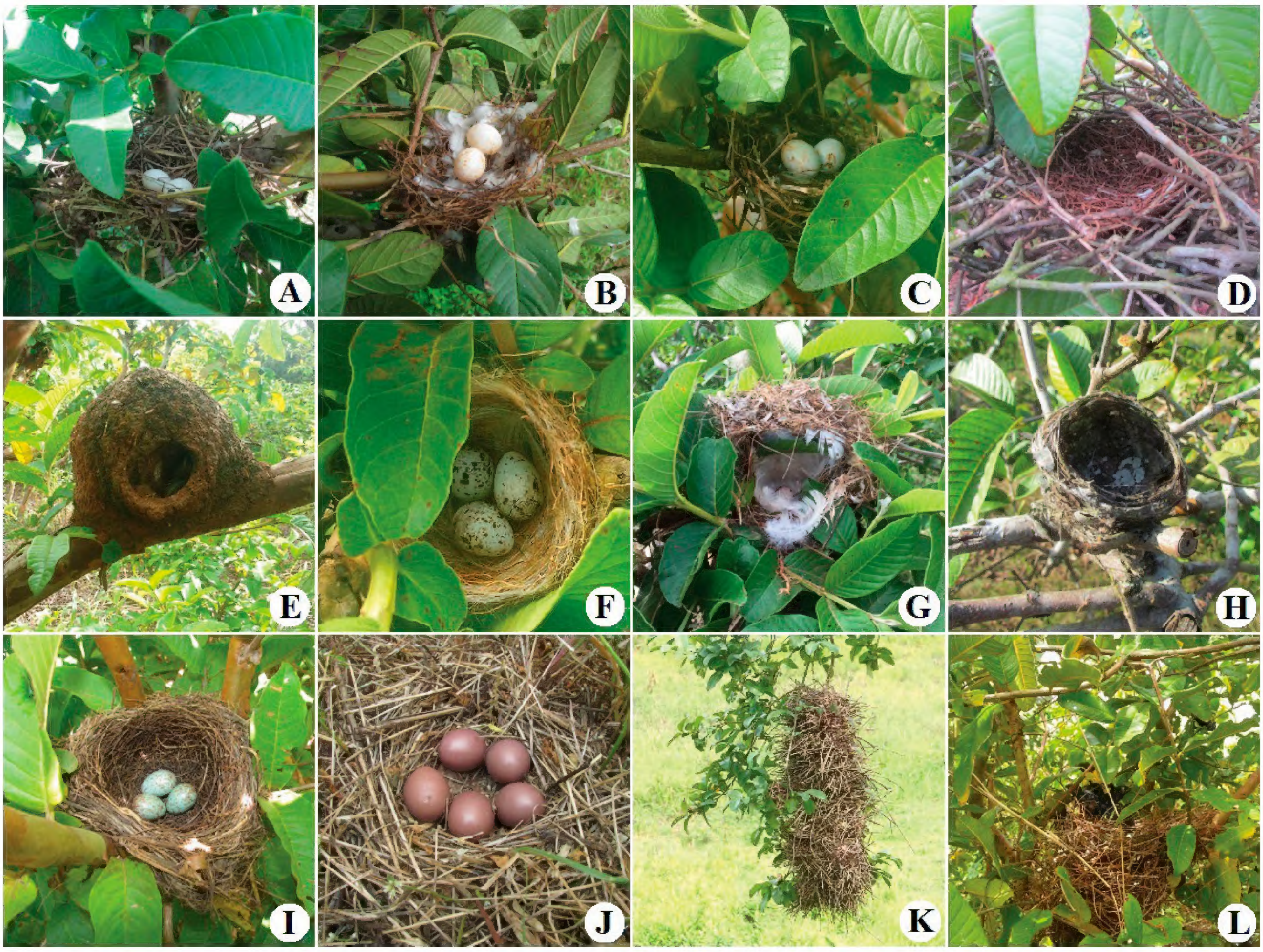


**Figure 4.** Nests of birds that used the sampled guava orchards, located in Sergipe, northeastern Brazil, for reproduction. A) *Columbina talpacoti*, B) *Columbina picui*, C) *Columbina minuta*, D) *Mimus saturninus*, E) *Furnarius rufus*, F) *Sporophila albogularis*, G) *Fluvicola nengeta*, H) *Polioptila plumbea*, I) *Turdus rufiventris*, J) *Crypturellus parvirostris* K) *Phacellodomus rufifrons*, L) *Crotophaga ani*. Photos: Cleverton da Silva.

(IFL: 0.48), *Columbina talpacoti* (IFL: 0.45), *Columbina picui* (IFL: 0.45), *Crotophaga ani* (IFL: 0.45) and *Pitangus sulphuratus* (0.43) (Fig. 3) were the most frequent among the bird species recorded in the sampled guava orchards, as they present high values of relative abundance or IFL (Table 1). Regarding the trophic groups, omnivores were the most representative in number of species (n = 35 species; 46%), followed by insectivores (n = 18; 23%) and granivores (n = 15; 19%) (Table 1). The nectarivores, granivores/frugivores, carnivores and piscivores were the least represented groups in number of species (Table 1).

One hundred and eighty-six nests were recorded, belonging to 12 bird species (Fig. 4), distributed in 10 families (Table 2). The species with the highest number of recorded nests were *Columbina picui* (n = 69 nests; 37%), *Columbina talpacoti* (n = 53 nests; 28%) and *Columbina minuta* (n = 22 nests; 12%).

## Discussion

The recorded bird richness in the 39 guava orchards sampled (n = 76 species) corresponds to only 38% of the total of 197 species already described for the semiarid

region of the state of Sergipe (Sousa 2009; Ruiz-Esparza et al. 2011, 2012; Ruiz-Esparza 2014). It is possible that with the removal of the native vegetation from the Caatinga to make way for the guava plantations, some species of birds have disappeared.

All bird species recorded in this study were documented in studies already carried out in the semiarid region of Sergipe (Sousa 2009; Ruiz-Esparza et al. 2011, 2012; Ruiz-Esparza 2014), except the White Monjita (*Xolmis irupero*), corresponding to the first documented record of the species for the state of Sergipe. The recording of bird species associated to water bodies inside the orchards, such as *Tachybaptus dominicus*, *Tigrisoma lineatum*, *Ardea alba*, *Gallinula galeata*, *Pardirallus nigricans*, *Jacana jacana*, *Chloroceryle amazona*, and *Fluvicola nengeta* is related to the presence of small lakes located inside these orchards.

The total number of bird species found in the present study was lower than that observed in Silva-Andrade (2016) (n = 83 species), in a study carried out in conventional and unconventional agricultural systems in the semiarid region of Pernambuco. It was also lower than that of Tejeda-Cruz and Sutherland (2004) (n = 80 species) and Leyequién et al. (2010) (n = 181 species), in coffee plantations. On the other hand, the number of bird species recorded in this study was higher than that recorded in Campolim (2011) (n = 57 species), in orchards of *Citrus reticulata*; Amit et al. (2014) (n = 42 species) and Almeida et al. (2016) (n = 58 species), in oil palm plantations; Mangan et al. (2017) (n = 59 species), in apple orchards; and in Alexandrino et al. (2019) (n = 72 species), in sugarcane fields.

Some of the bird species observed in guava orchards, such as *Crypturellus parvirostris*, *Bubulcus ibis*, *Vanellus chilensis*, *Columbina talpacoti*, *Crotophaga ani*, *Furnarius rufus*, *Pitangus sulphuratus*, *Tyrannus melancholicus*, *Troglodytes musculus*, *Tangara sayaca*, *Volatinia jacarina* and *Euphonia chlorotica*, were common to the studies by Estrada and Estrada (1997), Tejeda-Cruz and Sutherland (2004), Torresan (2010), Campolim (2011), Silva-Andrade (2016). These results reinforced the tolerance of this bird species to disturbances provoked by agricultural environments.

The representation of the Tyrannidae and Thraupidae families in a number of species has also been observed in other studies carried out in rural areas, especially in agricultural environments (Torresan 2010; Campolim 2011; Kohl and Treco 2012; Marcelino et al. 2014; Mencato and Treco 2016; Silva-Andrade 2016). Furthermore, these families are among the most abundant in the Brazilian northeastern semiarid region (Silva et al. 2003). Tyranids form one of the groups of birds in the Neotropical region with the highest number of species (Sibley and Monroe Jr. 1990). Their representatives have great behavioral variation that enable them to occupy a huge variety of environments and ecological niches (Traylor and Fitzpatrick 1982). Characteristics that justify the greater record of these species in several studies. Likewise, the Thraupidae family has many species with wide geographic distribution (Sick 1997).

The prevalence of omnivorous, insectivorous and granivorous species in guava orchards is similar to the pattern of occurrence observed in other tropical anthropogenic environments (Tejeda-Cruz and Sutherland 2004; Scherer et al. 2005; Filho and Silveira 2012; Alexandrino et al. 2017; Vitorino et al. 2018). The predominance of non-specialized omnivores and insectivores in altered environments is common,

as these trophic guilds are mainly composed by generalist species that can benefit from anthropogenic changes in the environment, mainly in terms of food availability (Willis 1979; Sick 1997; Chace and Walsh 2006). The granivores, represented mainly by species of Columbidae and Thraupidae, are probably benefited by the presence of swiddens and grasses that usually develop in these types of environments (Anjos 1998). According to Şekercioğlu (2012) and Vitorino et al. (2018), granivores benefit from abundant food in open tropical agricultural environments and this group appears to use guava orchards equally well in the region.

Birds that were observed using the guava orchards for nesting events account for 16% of the total 76 bird species recorded in the present study. According to Koopman and Pitt (2007), some monocultures can offer not only abundant food, but also substrate for nesting to the birds. The importance of these areas, such as orchards, for example, for some bird species, especially during the breeding season, has already been documented (Bouvier et al. 2005; Wiącek and Polak 2008).

In a study conducted by Mateus (2013), in commercial guava orchards in the Zona da Mata of Minas Gerais, it was also observed that some bird species used the area both for feeding and nesting. She identified and confirmed the presence of seven species of birds that visit orchards in search of food and six species in search of nesting places. Of these, *Tangara sayaca*, *Columbina talpacoti* and *Sporophila* spp. were recorded using the guava orchards. The first was observed feeding on guavas and the others using the orchards as nesting areas, as observed in this study. Campolim (2011), in tangerine orchards in the state of São Paulo, observed seven bird species using the area for nesting. However, only *Columbina talpacoti* matches the species observed in this study.

In conclusion, bird species recorded in the guava orchards are common in the semiarid region (caatinga) of the state of Sergipe, except by the White Monjita (*Xolmis irupero*), a new record for the state. Also, all bird species recorded using the guava orchards are considered disturbed-tolerant species. In general, the guava orchards are not acting as a refuge for the conservation of birds in the semiarid region of Brazil in a satisfactory manner, as they are excluding species sensitive to human disturbances. However, they are being used by five endemic species, showing that these habitats can be important for at least some of the birds living in the Caatinga. Thus, the adoption of some agroecological practices, such as the planting of some shrub and/or native tree species in association with the cultivation of guava, can be applied to attract species of high conservation value, such as the endemics (Perfecto and Vandermeer 2008). These practices are in line with Conservation Biology (Primack and Rodrigues 2001) and with the concept of sustainable agriculture that admits that certain areas can be used simultaneously for agricultural production and for the conservation of biodiversity.

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